1. Name of Experiment/Project/Collaboration: DAEdALUS
2. Physics Goals
    a. Primary: Measuring δcp
    b. Secondary: Sterile neutrino, dark-photon, cross section and other short baseline studies with a pi/mu DAR source
3. Expected location of the experiment/project: For the primary physics, HyperK or other >300kt water based detector, ASDC, LENA or other >50 kt LS detector. For the secondary physics, any of the above as well as SuperK or NOvA.
4. Neutrino source: pion and muon decay at rest
5. Primary detector technology: ultra-large detectors with large free-proton component
6. Short description of the detector –

    Here we describe the sources, which is the subject of the DAEdALUS program:
    The sources consist of a compact injector cyclotron (60 MeV) and a superconducting ring cyclotron (800 MeV). The sources are arranged at three sites, at <1.5 km, ~8km and 20 km from the ultra-large detector. The third site uses two sources, which are modified for high power by each having two injector cyclotrons.
7. List key publications and/or archive entries describing the project/experiment.
    1) **Multiple Cyclotron Method to Search for CP Violation in the Neutrino Sector** - Conrad, J.M. *et al.* Phys.Rev.Lett. 104 (2010) 141802 arXiv:0912.4079 [hep-ex]
    2) **Engineering Study of Sector Magnet for the Daedalus Experiment** - Minervini, Joseph *et al.* arXiv:1209.4886 [physics.acc-ph]
    3) **Whitepaper on the DAEdALUS Program** - Aberle, C. *et al.* arXiv:1307.2949
8. Collaboration
    a. Institution list

    US Academic Institutions: Amherst College, Columbia University, Duke University, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, Massachusetts Institute of Technology, Michigan State University, New Mexico State University, University of California, Berkeley (Nuclear Engineering), University of California, Irvine, University of California, Los Angeles, University of Maryland, University of Tennessee

    International Academic Institutions: LNS-INFN (Catania), The Cockcroft Institute for Accelerator Science & the University of Manchester, Imperial College London, Paul Scherrer Institute, University of Huddersfield,, RIKEN, Tohoku University

    Industrial Institutions: AIMA, Best Cyclotron Systems, IBA

    b. Number of present collaborators : 50
    c. Number of collaborators needed.: 50 or more

9. R&D
    a. List the topics that will be investigated and that have been completed

    Our R&D requirements were vetted by an external committee in the Galambos Report: (http://arxiv.org/abs/1308.4719) and our R&D approach is a phased program. Phase 1, which is understanding the low energy beam transport is >75% complete, and a paper will be submitted in early 2015. Phase 2, IsoDAR, which develops the injector cyclotron is well underway. Phase 3, which is to produce a near site, has some completed engineering (see ref. 2 above). Phase 4, which addresses questions associated with reaching high intensity, is in the conceptual design stage.

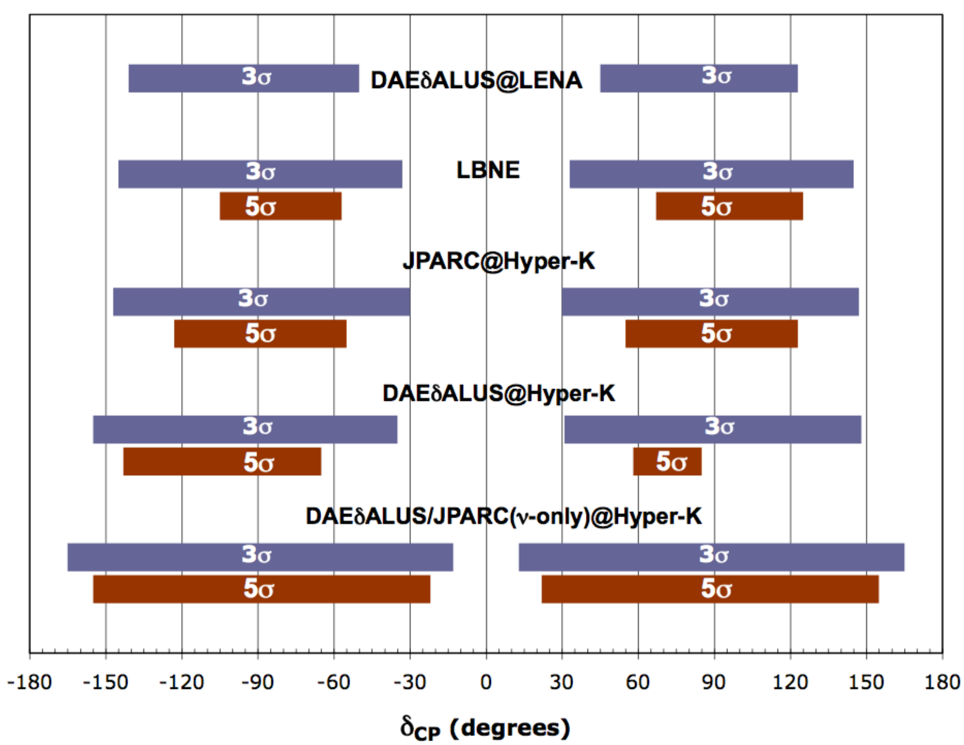
b. Which of these are crucial to the experiment: All are crucial.
c. Time line: A technically driven schedule completes the source in 2024.
d. Benefit to future projects: We are building a source which is useful when paired with many detectors. So this has substantial impact on the future opportunities in the HEP community. Beyond this, our work is having a major impact in the cyclotron community. For example, the OPAL code, which is the equivalent of GEANT4 of that community, now has capability to describe spiral inflectors in 3-D due to our work. We also note that establishing a cyclotron system of the design we propose is of substantial interest to the ADS (thorium reactor) community.

10. Primary physics goal expected results/sensitivity:

a. For exclusion limit (such as sterile neutrino search), show 3-sigma and 5-sigma limits

b. For discovery potential (such as the Mass Hierarchy), show 3-sigma and 5-sigma.

The δ_{CP} regions where an experiment can discover CP violation by excluding $\delta_{CP} = 0^0$ or 180^0 at 3σ or 5σ. DAEdALUS@Hyper-K and DAEdALUS@LENA refer to using the DAEdALUS source only at the given detector. DAEdALUS/JPARC (ν-only)@Hyper-K refers to combining the DAEdALUS@Hyper-K data set with a normal JPARC beam ν-only data set. All estimates are for 10 years total running as presented in the table below. (Plot and Table are from Cyclotrons as Drivers for Precision Neutrino Measurements, A. Adelmann, et al., arXiv:1307.2949.)

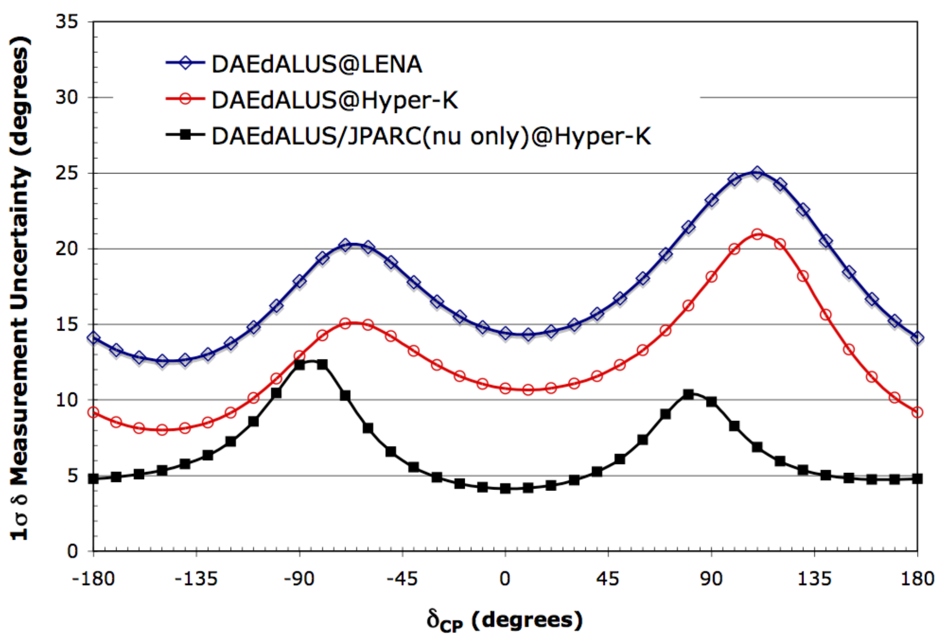


Configuration Name	Source(s)	Average Long Baseline Beam Power	Detector	Fiducial Volume	Run Length
DAEδALUS@LENA	DAEδALUS only	N/A	LENA	50 kt	10 years
DAEδALUS@Hyper-K	DAEδALUS only	N/A	Hyper-K	560 kt	10 years
DAEδALUS/JPARC (nu only)@Hyper-K	DAEδALUS & JPARC	750 kW	Hyper-K	560 kt	10 years
JPARC@Hyper-K	JPARC	750 kW	Hyper-K	560 kt	3 years ν + 7 years $\bar{\nu}$ [93]
LBNE	FNAL	850 kW	LBNE	35 kt	5 years ν 5 years $\bar{\nu}$ [89]

Table 5: *Configurations considered in the various CP violation sensitivity studies.*

c. For sensitivity plots, show 3-sigma and 5-sigma sensitivities
(note that for neutrino-less double beta decay experiments that have previously been asked for 90% CL and 5 sigma limits these are OK)

In combination with the above 3-sigma and 5-sigma discovery regions, we present below the 1-sigma error for measuring the δ_{CP} parameter with 10 years of data. The most accurate measurement comes by combining the DAEdALUS@Hyper-K data set with a normal JPARC beam, ν-only data set. (See arXiv:1307.2949)



d. List the sources of systematic uncertainties included in the above, their magnitudes and the basis for these estimates.
For simplicity, we quote from reference 1:

The largest systematic errors arise from the ν_eES sample used to determine the absolute normalization of the flux. The error on this cross section is 0.5% due to a 0.7% uncertainty from the NuTeV $\sin^2\theta_W$ measurement [20]. We assume a 2.1% energy scale error [21] which leads to a 1% error on the DAR flux when a $E_{vis} > 10$ MeV cut on the events is applied. The ν_e events on oxygen and IBD events with a missing neutron can be separated from the ν_eES sample since the angular distribution of ν_eES events is very forward-peaked, while these backgrounds have a broad distribution [19]. We take the uncertainty from contamination by these events to be negligible. The uncertainty of the electron-to-free-proton ratio in water is also very small. Adding the ν_eES systematics in quadrature, the systematic error on the IBD flux is expected to be 1.1%. For the total error on the IBD flux, one must then add the ν_eES statistical error in quadrature, which depends on the running period.

The other significant systematic error is on the efficiency for neutron detection in IBD events. To reduce uncertainties, neutrons are tagged via timing rather than position reconstruction. This leads to an inefficiency for neutrons outside of the timing window with a systematic uncertainty of 0.5% [12].

e. List other experiments that have similar physics goals
   The set of long baseline numu to nue appearance experiments

f. Synergies with other experiments.
   Above, we discuss the value of combining the result with long-baseline appearance experiments. Note that the short duty factor of the long-baseline beam, as well as the higher beam energy, allows for simultaneous running with DAEdALUS. The design of our experiment is unique and complementary to the other experiments in the following ways: 1) This measurement has no matter effects, unlike the long baseline appearance approach. 2) the E and L of the search is quite different from the long baseline designs, hence providing unique sensitivity to NSI's when comparisons are made.

11. Secondary Physics Goal
    a. Expected results/sensitivity
       We and others have published many papers showing unique sensitivity to sterile neutrinos, dark photons, and cross sections of interest to supernovae studies. Rather than provide many plots here, we recommend the following articles as some examples:
       - **Short-baseline Neutrino Oscillation Waves in Ultra-large Liquid Scintillator Detectors** - Agarwalla, Sanjib Kumar *et al.* JHEP 1112 (2011) 085 arXiv:1105.4984 [hep-ph] EURONU-WP6-11-32, IFIC-11-22
       - **Coherent Neutrino Scattering in Dark Matter Detectors** - Anderson, A.J. *et al.* Phys.Rev. D84 (2011) 013008 arXiv:1103.4894 [hep-ph]
       - **Measuring Active-to-Sterile Neutrino Oscillations with Neutral Current Coherent Neutrino-Nucleus Scattering** - Anderson, A.J. *et al.* Phys.Rev. D86 (2012) 013004 arXiv:1201.3805 [hep-ph]

- **Neutrino nucleus cross-section measurements using stopped pions and low-energy beta beams** - McLaughlin, G.C. Phys.Rev. C70 (2004) 045804 nucl-th/0404002
- **DAEdALUS and Dark Matter** - Kahn, Yonatan *et al.* arXiv:1411.1055 [hep-ph] MIT-CTP-4591

b. List other experiments that have similar physics goals
OscSNS, KDAR

12. Experimental requirements
    a. Provide requirements (neutrino source, intensity, running time, location, space,…) for each physics goal
    Three sites are located at <1.5, 8 and 20 km, respectively. The sites are run consecutively on the time scale of milliseconds, leaving 40% of the run-time as beam-off for background measurement. The average power at the sites is 1, 2 and 5 MW. The cyclotrons can have multiple extraction lines, so that we maintain 1 MW on each beam dump. The near accelerator produces 4E22/flavor/yr of nue, numu and numubar (other sites scale according to power). The size of space needed at each complex is driven primarily by the superconducting cyclotron. For scale, this is the physical size of MiniBooNE (about 40 ft in diameter). Specifics of the cyclotron design are available upon request. We assume a 10 year run.

13. Expected Experiment/Project time line
    a. Design and development
    This is underway and we are well along with phase 2. We have many published papers on the design and have run many studies.
    b. Construction and Installation
    A technically driven schedule allows us to be installed by 2024 for the near-site running. The full program can be installed by 2029.
    c. First data
    The near site program needs ~1 year for many of the measurements
    d. End of data taking - 10 years after the start of running.
    e. Final results
    These should be more or less simultaneous with the end of running.

14. Estimated cost range
    a. US contribution to the experiment/project
    $329M (and $121M contingency). If needed, we can supply a letter from Steve Holmes of Fermilab agreeing that our cost estimates make sense. Note that this does not assume a green-field site. It assumes installation at a mine where an underground detector would be located, which already has power and water available. We assume all site costs are assumed by the host nation.

    International contribution would be negotiated.

b. Operations cost

   These depend upon where we run.   We assume if we run outside the US, then the host countries cover the utilities costs.

15. The Future

   a. Possible detector upgrades and their motivation.

      No upgrades are planned

   b. Potential avenues this project could open up.

      Our program of developing high power cyclotrons is unique in the US and could open a broad range of opportunities in HEP well beyond neutrino sources as well as medical/industrial applications.